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Statement of
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before the

Subcommittee on Space and Aeronautics
Committee on Science and Technology
U.S. House of Representatives

Chairwoman Giffords, Ranking Member Olson, and Members of the Subcommittee, thank you for the opportunity to appear before you today to provide a NASA perspective on the emerging use of biofuels for aviation, including the Agency's current research in this area.

Growth in the air transportation system is vital to the economic wellbeing of our nation. In order to meet the projected growth in aviation, significant challenges must be overcome including environmental sustainability. NASA is conducting cutting-edge research to dramatically improve aircraft efficiency and revolutionize aircraft operations in the national airspace system, both of which will reduce the environmental impact of aviation. An emerging technology area that has attracted considerable attention recently is the use of renewable energy sources such as aviation biofuels. Biofuels offer the potential for a significantly reduced carbon footprint over the entire life cycle, from fuel production to utilization. Current NASA research on increasing aircraft efficiency and operational procedures, coupled with the use of biofuels, presents a possibility to dramatically reduce the carbon footprint for the aviation sector despite the projected growth.

The first generation of biofuels, such as those produced from soybean and corn, is derived from food products and requires large landmasses. Second generation biofuels from energy crops such as switchgrass and woody feedstocks have higher productivity and smaller land use. The second and third generation of biofuels, produced from jatropha, camelina, algae, and halophytes, appears to impact much smaller landmasses and is not derived from food products, which is the reason for strong world-wide interest for this class of materials.

NASA recognizes the importance of biofuels for the future of aviation and in 2007 initiated a modest research effort that builds upon the existing expertise in fuel chemistry and processing, combustion, and gas turbine engines to address some of the challenges associated with the application of these fuels for aviation. However, NASA also recognizes that the widespread use of biofuels for aviation will require a concerted effort by multiple government agencies, aerospace industries, academia, and biofuel producers. The need for a coordinated approach to enabling new fuel sources is highlighted as one of the goals of the National Plan for Aeronautics Research and Development and Related Infrastructure. As noted in the plan, the Commercial Alternative Aviation Fuels Initiative (CAAFI) is coordinating development and commercialization of “drop-in” alternative aviation fuels and is considering the feasibility, production, and environmental footprint - “well to wake” - of these fuels.

Challenges

While recent successful flight tests, including the Air New Zealand flight demonstration in December 2008, the Continental airlines flight in January 2009, and the JAL flight in January 2009, have shown the feasibility of using blends of jet fuel and different types of biofuels under controlled conditions, several technical and economic barriers remain for widespread use of biofuels in the aviation sector. The challenges can be grouped into two categories: biofuel production and application of biofuels. Most of the NASA research in this domain focuses on issues related to the application of biofuels.

The major question related to the production of biofuels is whether they can be made sustainably, economically and at a scale sufficient to support the aviation industry. It is NASA’s opinion that additional basic and applied research will be required to scale up the process for producing large quantities of biomass that are economically viable and sustainable. This will require understanding the factors affecting the growth of biomass and translating that understanding to increase process yield. In addition, production processes that reduce energy use during the biomass to biofuel conversion process must be developed towards the goal of carbon neutrality, which can be achieved for the entire life cycle encompassing production and utilization of biofuels.

There are uncertainties related to the application of biofuels for aviation because of the extremely limited amount of testing conducted to date with these fuels. For alternative fuels not produced by the Fisher Tropsch (F-T) process, the knowledge base of the characteristics and qualities of these fuels is incomplete, and many of the challenges may not be known yet. In order to understand these challenges, foundational research is required in many areas. We need to study the combustion process using alternative fuels and understand whether the combustor performance is different from that achieved when jet fuel is used. Of particular concern is the long-term performance of combustors and turbine engines burning alternative fuels. Because nitrogen oxide (NO_X) causes ground-level smog and contributes to acid rain, the compatibility of alternative fuels with advanced, ultra-low NO_X combustor designs must be addressed as well.

Research will be needed to understand both gaseous and particulate matter emission characteristics from engines so that alternative fuels can be optimized for reducing emissions.

The other unknown is the effect of alternative fuels on the long-term durability of engine components, including advanced fuels from coal and natural gas.

The impact of the use of alternative fuels on aircraft safety is another area that needs further study. Flight tests with a blend of jet fuel and biofuels to date have been conducted under controlled conditions and have not yet indicated any major safety issues. However, one potential safety issue is leaks and degradation of seals in the aircraft fuel system because of the lower aromatic content of alternative fuels compared to that of jet fuel, which affects the expansion coefficient of seals. Any potential, unexpected degradation of engine components when alternative fuels are used could pose safety issues. Foundational research on the effect of alternative fuels on engine performance (including control system) and degradation of engine materials is required to identify potential safety issues and develop mitigation strategies.

Current NASA Research

NASA is conducting long-term foundational research to understand the effects of various alternative fuels on aircraft engine emissions. NASA intends to disseminate the results of its research to the greatest extent possible, and enters into collaborative relationships with other organizations such that the results will benefit the wider community. Research includes laboratory combustion testing under controlled conditions and ground engine testing under simulated flight conditions. NASA has recently modified several laboratory-scale combustion facilities to study combustion performance and emission characteristics with different types of alternative fuels and blends of alternative fuel with Jet-A. Research conducted in these facilities will provide the much needed emission data for alternative fuels as well as improved understanding of factors affecting gaseous and particulate emissions with the use of alternative fuels. An important feature of NASA's research is to understand the effect of alternative fuels on both gaseous and particulate emissions for advanced combustor designs that are being developed to reduce NO_X for future generations of aircraft.

All of NASA's research efforts on alternative fuels to date have been focused on the application of synthetic jet fuel produced from natural gas and gasification of coal and conversion of the gases to liquid fuel by the F-T process. Current research using F-T fuel is providing valuable insight into emission characteristics of alternative fuels. We are also studying ignition times, flame speeds, and chemical kinetics. These are parameters which affect the design of new combustors. As the second generation of biofuels becomes available, there is a need for research to understand these parameters for biofuels as well so that we can effectively design new low-emission combustors that are fuel-flexible. The understanding, coupled with improved emission prediction models, will enable the design of advanced, ultra-low emission engines with the flexibility to operate with a mix of fuels that range from blends of jet fuel with biofuel to 100 percent biofuel. Several examples of the type of alternative fuels testing conducted by NASA are provided below.

NASA, in partnership with industry, is conducting engine tests with alternative fuel to understand the emission characteristics. In 2008, NASA partnered with Pratt and Whitney to study emissions from a geared turbofan engine that was run with a blend of jet fuel and F -T fuel. The tests indicated that there was no significant difference in gaseous emissions, while confirming the benefits of F-T fuel in reducing particulate emissions. Initial results from these tests were presented at the Fundamental Aeronautics Program Second Annual Meeting held in Atlanta on October 7-9, 2008, and NASA will hold a workshop later this year to widely disseminate the results. In another collaboration with Pratt and Whitney, the U.S. Air Force Research Laboratory, Aerodyne, United Technologies Research Center, and NASA studied emissions from a PW308 turbofan engine run with 100-percent F-T fuel and a blend of jet fuel and F-T fuel. This study provided detailed understanding of the nature of particulate emissions resulting from the combustion of F-T fuel under engine operating conditions.

Recently, in January 2009, NASA, in partnership with 11 other organizations that include the Federal Aviation Administration, U.S. Air Force Research Lab (AFRL), Environmental Protection Agency, Boeing, GE Aviation, and Pratt & Whitney, conducted ground tests using a NASA-owned DC-8 plane to study emissions from engines burning alternative fuel, which included two 100 percent F-T fuels and blends of jet fuel with the two F-T fuels. The test provided data that will improve understanding of the evolution of particulate emission and plume chemistry for engines burning alternative fuel.

In addition to extensive experience in testing and analysis, NASA has expertise in multi-scale modeling of fluid mechanical processes. This is being recognized by the private sector engaged in the development of large scale processes for growth of the second generation biofuel biomass source material (such as algae and halophytes). In order to meet the challenges of large-scale production of second generation biofuel biomass economically, the fluid mechanical processes which transport nutrients and waste in the bioreactor need to be understood and modeled. The models can then be employed to design improved bioreactors that can reduce the cost of biomass production. NASA is working with industrial partners to develop multi-scale, fluid-mechanics models that integrate physical and biological processes in a bioreactor. NASA has laboratory scale reactors suitable for validating multi-scale, fluid-mechanics models to be used for improved bioreactor designs.

Need for Collaboration

NASA believes that long-term, foundational research on understanding of fuel processing, combustor and engine performance, durability of engine components, and emission characteristics will be required for application of second generation biofuels in aviation.

Realization of the full potential for the application of alternative fuels in aviation requires a coordinated effort among multiple government agencies, aerospace companies, academia, and fuel producers. This is an area of significant national importance and will require a strong national effort.

NASA participates in alternative fuel related road-mapping and planning activities that are underway, most prominently led by the Commercial Aviation Alternative Fuels Initiative, or

CAAFI. We also participate in Air Force led efforts to develop rules and tools for use in predicting the life-cycle greenhouse gas emissions of alternative fuels and are on the Advisory Board of FAA's PARTNER Center of Excellence which conducts alternative fuel emissions and life-cycle studies. We are willing to participate in this alignment of alternative fuels activities along with other government agencies, industries, and academia as appropriate.

These roadmaps are identifying the research, development, and demonstration needs, and defining the roles and responsibilities for multiple organizations. Continued participation in these planning activities will allow NASA to better coordinate its plans for foundational research on aviation biofuels. In addition, NASA will continue to work with the Aeronautics Science and Technology Subcommittee of the National Science and Technology Council to ensure that proper research objectives and goals are coordinated at the highest level.

Conclusion

NASA recognizes the high potential of alternative fuels for the aviation industry from the perspectives of protecting the environment and ensuring the long-term viability of the fuel supply. The Agency has initiated research activities to address some of the major challenges of alternative fuels development, fully recognizing that this is an emerging technology area that will require collaboration on research and development among multiple government agencies, industries, and academia to make biofuels a reality. NASA believes its expertise and research capabilities in combustion, turbine engine performance, fuel processing, materials, and computational modeling can be utilized as part of a nationally coordinated research effort to address some of the key challenges that must be overcome for widespread use of second generation biofuels in future aviation. Such research on biofuels will complement a diverse portfolio of technologies that NASA is working on to improve the efficiency and reduce the environmental impact of aviation in the future.

I would be happy to respond to any questions you or the other Members of the Subcommittee may have.